Fall 2020

Using Active Power Factor Correction in Power Supplies to Improve Power Quality

Luke Freigang

Using Active Power Factor Correction in Power Supplies to Improve Power Quality

In the most basic terms, a power supply converts the high voltage AC power delivered by outlets to lower voltage DC power usable by most devices. It does this with a bridge rectifier and several transformers. However, without a few key modifications power supplies can drastically reduce the quality of the power being supplied to a device.

Power Factor measures how much power a system is using compared to how much power it appears to be using. The ideal power factor for a system to have is 1. Power supplies traditionally include a large filter capacitor directly after the bridge rectifier which charges and discharges as it filters the voltage ripple. This constant charging and discharging causes the current flowing through the rectifier to come in bursts as can be seen in Figure 1.

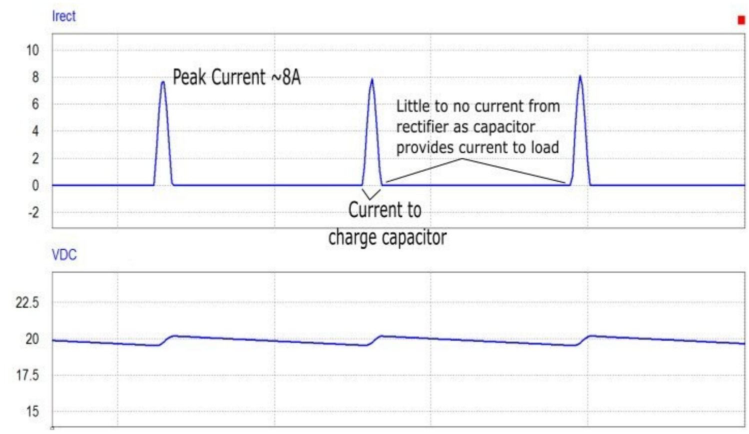

Figure 1

These bursts lower the power factor of the system and cause harmonic currents, both of which are bad for overall power quality. Additionally, the combined effect from millions of power supplies drawing current only in burst can cause problems for the whole power grid.

The clever solution engineers have come up with to combat this is know as power factor correction or PFC. PFC is implemented in one of two forms, active or passive. For power supplies over 100W Active PFC is generally preferred as it provides more efficient control. The Boost PFC converter is one of the most common ways to implement active PFC. It is constructed using a FET, a diode, and an inductor, an example of a boost PFC can be seen below in Figure 2.

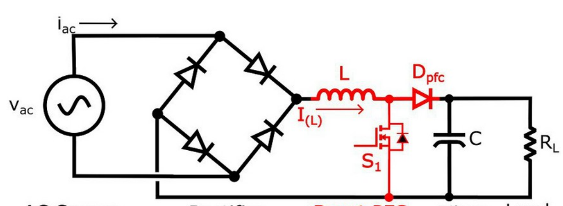

Figure 2

The Boost PFC circuit improves the quality of power by forcing i_{ac} to be more sinusoidal and in phase with V_{ac}. This is achieved by rapidly switching the FET, labeled S_1 in Figure 1, between its two states with a PID controller. When S_1 is open the current I_L decreases as the inductor provides energy to the load and charges the capacitor. When S_1 is closed the diode becomes reverse biased as the anode is connected to ground. The inductor is energized by i_{ac} and I_L increases. The capacitor provides the provides power to the load and both are "disconnected' from the rest of the circuit. S_1 changes states at a rate of at least 10kHz. Using a higher frequency allows you to use a smaller inductor. By changing the duty cycle of S_1 with a PWM signal the controller can modify the average current through the inductor. This allows us to force I_L and i_{ac} into whatever shape needed. Figure 3 shows how adjusting the duration of the charge and discharge cycles is used to synthesize a desired shape.

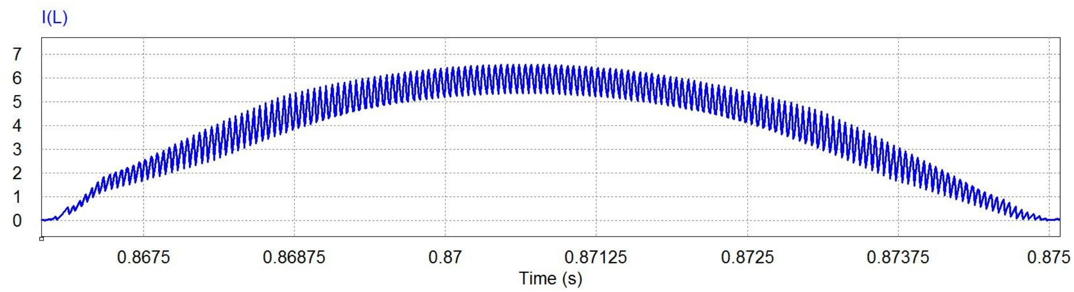

Figure 3

Forcing the current to approximately track the shape and phase of V_{ac} yields an improved power factor and prevents problematic bursts of current.

With millions of power supplies connected to the grid every minor inefficiency can lead to serious challenges. With many power supplies failing to meet the requirements outlined by IEC 61000-3-2 Active Power Factor Control circuits such as Boost PFC are crucial in designing modern power supplies. Their low-cost implementation and significant improvement to power quality makes them a must use tool for every electronics designer.